Agent Based Modeling(ABM)

Prediction & Estimation of safe re-opening date

March 1, 2020 ~ Aug 27, 2020

Author: Yeong Soo Kim Advisor: Prof. Hao Tang
Department of Computer Science

BFF BMCC Foundation Fund for Undergraduate Research

BMCC

Introduction

Background

After experiencing 14-day decline in the hospitalization rate, people start seeking some hope for re-open. Governor Cuomo set requirements that each region must meet to begin the reopening process. Today's poster will demonstrate Agent-based-modeling (ABM)simulation and let it estimate when the city will meet those requirements of re-opening.

Requirements of re-open

- Must have at least a 14-day decline in hospitalizations
- Must have at least a 14-day decline in hospitalized death or under 15 new hospitalizations/5 new deaths
- At least maintain under 70% medical capacity

Purpose / Task

- To build a credible model of COVID-19 spread
- A model-based simulation which shows high correlation with historical data (March 1 ~ May 8)
- Simulate up to Aug 27(180 days from March 1) to predict the outcome.
- Determine the limitations from this simulation and find a way to make better.

Materials

Testing population	10700 people
Area Coverage	$1 km^2$
Infection Range	25m
Initial # of Infected	5 people
Date	March 1, 2020 ~ Aug 27, 2020
Tool for simulation	R

	Age1(0 – 17)	Age2(18 – 44)	Age3(45 – 64)	Age4(65 - 74)	Age5(74 <)
Female	1095	2351		42	358
Male	1152	218	47	3	224

km^2

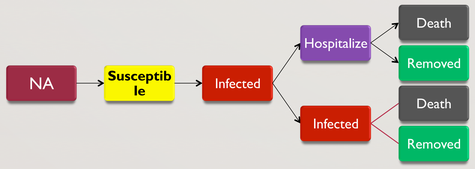
NYC demographics in 1 km^2

The following proportion of demographics is distributed randomly based on the fact from following link:

https://worldpopulationreview.com/states/new-york-population/

Methodology

Model flow



Probability for each Spread

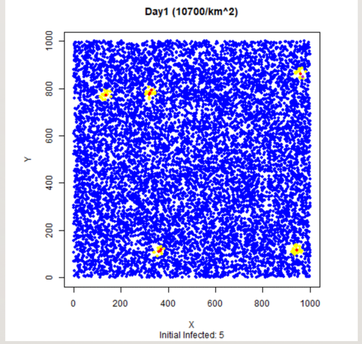
- P(S) {■1, $d < r$ □0, $d >= r$
- P(I) { ■$G \cdot A/p$, not hospitalized □$G \cdot A \cdot H/p$, hospitalized
- P(R){ ■$G \cdot A \cdot R/p$, not hospitalized □$G \cdot A \cdot H \cdot R/p$, hospitalized

Baseline parameters value

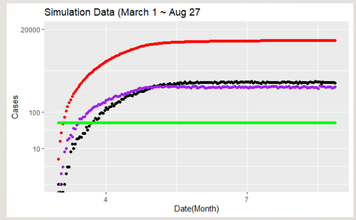
(%)	Age1(A)	Age2(A)	Age3(A)	Age4(A)	age5(A)
Male(M)	1.03	8.99	14.09	14.07	16.35
Female(F)	0.88	7.28	11.94	11.92	13.85
Hospitalize(H)	0.37	3.99	15.97	30.95	48.72
Remove(R)	15 30	15 30	15 30	15 30	15 30
Death(D)	0.06	0.87	7.96	26	65.13

Results

Simulation
March 1, 2020 ~ May 14, 2020



Simulation
March 1, 2020 ~ Aug 27, 2020



Aug 27 Demographic Status

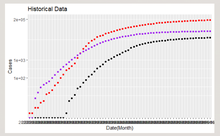
	Infected	Hospitalized	Removed	Death
Female	3609	271	900	459
Male	3444	229	737	194

	Infected	Hospitalized	Removed	Death
Age1	1372	4	238	0
Age2	3675	114	705	39
Age3	1684	264	456	201
Age4	292	102	153	186
age5	30	16	85	227

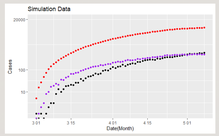
The medical beds in NYC counted as 41333, which averages 52 beds per 1km^2. Demographic shows total 500 patients hospitalized, which exceeds the limit. Yes, there are extra beds to take care of patients for now like in Central Park, but those are temporary. In order to meet requirements of re-opening, at least 30% of 'Hospital' beds should be available.
The green line in the graph represents boundary of 70% medical capacity. If the hospitalized rate(purple line) records under the boundary,

https://www.bloomberg.com/graphics/2020-new-york-coronavirus-outbreak-how-many-hospital-beds/

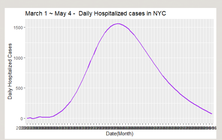
Reality



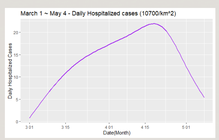
Simulation



Reality



Simulation



The following graphs represents each spread cases over time. Color red line represents confirmed(infected), purple is hospitalization, and black is death. Simulated graphs were averaged after 10 times of simulation, and each corresponding graphs show over 0.95 correlations. The daily hospitalization graphs on the bottom is only 0.5 correlated, however the simulation showed some significance that daily rate has ben declining for 14 days.

Conclusion

Unfortunately, this simulation could not lead to meet the requirements of re-opening. It shows the daily-hospitalization rate has declined for 14 days but remains almost stationary.
It is still in search of answers for such phenomenon, and some potential factors are:

- The region of NYC is too large to average for comparison.
- Not yet perfect in code
- This phenomenon is they way it should be.

Either way, there are some uncertainty to trust completely. Further research and deeper investigation is needed to proceed.

Discussion

Next step of progress:

- Determine more detailed demographics in smaller regions/ counties to split them categorically, then run the simulation with more precise variables.
- Determine reasons why rates remains almost stationary after reaching the peak. (revise code or reform the model.)
- Search better platform in simulation (non-static agents preferred)
- List 20 different regions/countries outside U.S(especially in Asia) that show high correlation between NYC. Determine the region/country that is environmentally similar to NYC. Since most of countries in Asia faced disaster generally 2-4 weeks earlier than U.S, and this would be good to project short future in U.S.

Acknowledgement

Special Thanks to:

Professor Hao Tang, Department of Computer Science
Thank you for giving me a huge trust and moral support.
I received more than what I gave you. You tried to give a support even in this lockdown, when I was stressed and burned out.
Anything to pay you back, I will do it. Hope to see you after the this is over.